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AERODYNAMIC METHOD FOR MAKING TISSUE PAPER

FIELD OF THE INVENTION

The present invention relates to the field of papermaking, and more particularly, to a method of manufacturing tissue paper featuring enhanced absorbency.

BACKGROUND OF THE INVENTION

One of the main problems that one encounters when making tissue paper by an aerodynamic method without using binders is the ability to provide a tissue paper having both a high absorbency (hygroscopicity) and sufficient strength. This is so because when the aerodynamic method is used without binders, the bonding of fibers is obtained from hydrogen bonds formed as a result of pressure processing and subsequent drying of the moistened layer of fibers produced from aerosuspension. Pressing of the fibrous layer is necessary to provide a greater area of inter-fibrous contact, while a drying is required to remove water molecules and form the above-mentioned hydrogen bonds between the fibers. Thus, the greater the pressure, the stronger the tissue produced and the lower its absorbency, and vice versa.

One conventional aerodynamic method of paper making comprises forming of a layer of cellulose fibers out of aerosuspension, impregnating

this layer by a liquid reagent, and subsequently pressing and drying of this layer. See, for example, USSR Author's Certificate 1594237, IPC 5 D21H 23/00, 21/18, published August 23, 1990. This method is characterized by the use of 2 - 8% water solution of resorcin that provides much better swelling of fibers than water. Penetration of water into intercrystalline space of pulp fibers facilitates enhancement of their plasticity, which results in more complete contact of fibers during pressing and drying, and, hence, enhances the strength of fiber bonding. Since molecules of resorcin form bonds of a "cellulose-resorcin-cellulose" type, resorcin also performs the function of a binder, which also facilitates the enhancement of the produced tissue strength. Thus, when using a water/resorcin solution for moistening the fibrous layer, one can decrease the pressure applied at the stage of pressing, thereby improving tissue absorbency while preserving tissue strength. However, introduction of chemical additives makes tissue paper production more expensive.

Another conventional method for making high-absorbency products out of fibrous materials comprises forming of a multi-layer structure of thin paper layers and a layer of fibers produced out of aerosuspension and placed between paper layers. All the layers arranged in the above manner are pressed between rolls, one of which has a patterned surface. See, for example, USA patent 3908653, IPC 2 A61F 13/16, A61L 15/00, published September 30, 1975. Final formation of the product proceeds in the

following manner: two structures obtained in the above-described way are folded together facing each other with patterned surfaces and then the edges are jet-molded or glued together. Since the filler in the product comprises substantially non-pressed fibers, the final product offers high hygroscopicity, but the manufacturing cost of such products is very high.

One conventional aerodynamic method of papermaking, which is believed to be the closest to the present invention, comprises preparation of aerosuspension of cellulose fibers, forming a fibrous layer on a moving forming wire, moistening the moving fibrous layer with water, the amount of which constitutes 20 - 60 % of fiber weight, and subsequently pressing and drying of said fibrous layer. See, for example, USA patent 3949035, IPC 2 B29C 17/04, published April 6, 1976 - prototype. Pressing is performed between two rotating rolls, one of which has a patterned surface made in the form of ridges with flat faces of round (or circular) shape, and the distance between ridges doesn't exceed the average length of the cellulose fibers. During pressing, compaction of the fibrous layer and formation of greater contact area between the fibers take place in the ridge areas, while no compaction occurs in the areas between the ridges (i. e., in valleys). As a result, the final product obtained after drying has two types of areas: areas of a pressed fibrous layer that determine the strength of the tissue paper, and areas of non-pressed fibrous layer that determine tissue

absorbency. Thus, this method enables one to produce tissue paper, the structure of which concurrently provides tissue strength and hygroscopicity.

At the same time, to provide the formation of the above-mentioned inter-fibrous bonds, the formed fibrous layer should be moistened with a substantial amount of water. Besides, to provide better penetration of water into the fibrous layer, this moistening is accompanied by rarefaction of air produced underneath the wire carrying the fibrous layer. Such a moistening process requires amounts of water that are excessive compared to the amounts needed for the formation of inter-fibrous bonds. In addition, it takes an extra time to moisten the entire fibrous layer. All the above results in extra expenditures of energy (mainly expended on subsequent drying of the tissue paper web) and slows down the process of tissue production. Besides, removal of great amounts of water through drying leads to the shrinkage of the non-pressed part of the fibrous layer, which results in a decrease in absorbency of the produced tissue paper.

SUMMARY OF THE INVENTION

The present invention advantageously decreases the costs related to the manufacture of tissue paper and increases of the quality of the tissue paper.

According to an embodiment of the present invention, a method of making tissue paper comprises the following steps: preparing an

aerosuspension of fibrous material; forming a layer of fibers on a forming wire; transferring the layer of fibers to a profiling belt having a pressing surface containing protruding elements for impressing first areas of the fibrous layer in contact therewith; contacting the layer of fibers disposed on the pressing surface of the profiling belt with a moistening belt; and pressing the layer of fibers between the profiling belt and the moistening belt. In addition, the moistening belt has a lower sorption capacity than a sorption capacity of the first areas of the fibrous layer being impressed by the protruding elements and higher than a sorption capacity than second areas of the fibrous layer that are not impressed by the protruding elements.

According to the present invention, a distance between protruding relief elements on the pressing surface does not exceed an average length of the fibers. The formed layer of fibers can be placed on a profiling belt that has a pressing surface that faces the layer of fibers. Moistening of the formed layer of fibers is performed concurrently with the pressing step, an utilizes an additional belt such as, for example, a moistening belt. The moistening belt is disposed such that a pressing force is exerted concurrently on the profiling belt, the moistening belt, and the layer of fibers located therebetween. The moistening belt is preferably made of a material having a sorption capacity that is lower than a sorption capacity of those areas of the layer of fibers that are pressed due to the protruding

relief elements, but higher than the sorption capacity of the areas of the layer of fibers that are not pressed by the relief elements. The moistening belt can be saturated with an appropriate fluid such as, for example, water, in an area that is outside the pressing zone.

In one embodiment of the claimed invention, the fibrous layer placed between the profiling and moistening belts during the step of pressing. In the course of pressing, the sections of fibrous layer that are in the areas of protruding relief elements get compacted, which results in an increase of absorbency of the fibrous layer, due to the increase in the pressure of capillary absorption. When the fibrous layer absorbency reaches a value equal to the value of the same parameter of the moistening belt, the sections of the fibrous layer being compacted begin to absorb water from the moistening belt surface. With further compaction of the fibrous layer the excess water is squeezed out from the compacted sections into the non-compacted sections, and due to the difference in capillary absorption pressures, this water returns to the moistening belt. Part of the water returned will subsequently be absorbed by new sections of the layer of fibers being compacted. The moistening belt receives water required for moistening outside the pressing zone, for example, absorbing it when being passed through a tub with water.

The present invention provides concurrent moistening and pressing of the fibrous layer in order to minimize the amount of water required at the

pressing stage. Selective moistening of fibers only in the sections being compacted eliminates the requirement for moistening the entire fibrous layer, and excessive moistening. As a consequence, drying of the tissue paper web after the pressing step requires significantly lower expenditures of time and energy. Additionally, shrinkage of the tissue paper web is eliminated because the non-pressed sections of the fibrous layer are not moistened.

A wire made by means of interweaving threads can be used as the profiling belt. In this instance interweaving nodes represent the protruding relief elements of wire surface, and the shape of flat areas can be endowed through the use of smoothing. This approach can significantly reduces the cost of the process of the present invention.

Another simple and inexpensive embodiment of a moistening belt comprises a fine-mesh wire. In this instance sorption properties of the moistening belt are determined by surface properties of the material of the wire, as well as by relative sizes and geometrical configurations of threads and openings of the wire.

Further, longitudinal twisting of fibers that significantly decreases the area of contact between fibers in the areas pressed can be prevented if the prepared aerosuspension has a moisture content sufficient for causing saturation of fibers' walls with moisture.

BRIEF DESCRIPTION OF THE DRAWINGS

Fig.1 is a process diagram illustrating the process of moistening and pressing of a fibrous layer according to an embodiment of the present invention.

Fig.2 is a top plan view illustrating a profiling belt made in the form of wire, having smoothed surfaces of nodes produced by intersections of threads.

DETAILED DESCRIPTION OF THE INVENTION

Referring to Fig. 1, a pressing unit of a paper-making machine that uses the method of the present invention comprises a roller press having two pressure rollers 1 and 2, a profiling belt 3, a moistening belt 4, and a tub 5 with water into which a drum 6 is submerged. The drum 6 is intended for transporting the moistening belt 4 through the tub 5. Fig. 1 also shows a forming wire 7 on which fibrous layer 8 is formed, a drying drum 9, and wire-driving rollers and take-up suction rolls 10 and 11.

The profiling belt 3, a fragment of which is shown in Fig. 2, can be made out of wire comprising interweaving threads 12 and wefts 13 of round (circular) cross-section. The nodes of this wire on the side contacting the fibrous layer are smoothed to such an extent that flat pressing surfaces 14 of elliptic shape are produced, and said flat pressing surfaces 14 determine the fibrous layer sections to be pressed. Geometric size of the wire and

the surfaces 14 are selected so that a distance between the surfaces 14 of juxtaposed nodes of the wire doesn't exceed an average length of the fibers. The strongest paper retaining good absorbing properties can be produced when this distance is approximately equal to half of the average length of the fibers. In this instance the individual fibers interconnect with each other and transmit mechanical stresses arising in the conditions of paper break from one pressed area to another.

Fibrous layer 8 formed out of aerosuspension (forming process is not shown in Fig.1) through the use of the forming wire 7 and the profiling belt 3 is supplied to a zone of the suction roll 10 where the forming wire 7 breaks away, and the side of the fibrous layer 8 that has just lost contact with the forming wire is covered by the moistening belt 4. Such a forming belt can be made, for instance, in the form of a fine-mesh wire. The fibrous layer 8, now positioned between the profiling belt 3 and the moistening belt 4, is then fed to a pressing operation between rolls 1 and 2. Pressing of the fibrous layer 8 proceeds as described in the Summary of the Invention above. Subsequent to pressing, the belt 4 breaks away in the area of a take-up suction roll 11, and the pressed fibrous layer is fed to the drying drum 9, from which the finished paper web is subsequently obtained.

The possibility of implementing the claimed method was experimentally tested in a following manner.

Samples of tissue paper with specific weight of 40 - 45 g/m^3 were produced. Softwood and hardwood sulfate bleached pulp (with the average length of fibers 2.7mm and 1.4 mm, respectively) were used as fibrous semi-finished material.

An aerosuspension of fibers was prepared out of fibrous semi-finished material that has been moistened in advance to a moisture content of 50%. This aerosuspension was fed to the forming wire where a fibrous layer having a specific weight of 15 - 20 kg/m^3 was formed. A wire of interwoven synthetic threads 0.25mm in diameter and with the distance of 0.25 mm between core threads and 0.3 mm between weft threads was used as forming wire.

The formed fibrous layer (the moisture content of which was 30 - 35% at this technological stage) was transported to the profiling belt represented by standard metal wires #1 or #2 of simple interweaving generally used in papermaking industry. Wire #1 is woven out of flat threads, and the shape of its meshes is square. There are eight threads per 1 cm of running length, thread width is equal to 0.6 mm; thread thickness = 0.15 mm; distance between threads = 0.65 mm, and the area of threads constitutes 70% of the total wire area.

Wire #2 is woven out of threads of round section and of diameter 0.5 mm, and the shape of its meshes square. There are eight threads per 1

cm of running length, and the distance between threads is 0.75 mm. One surface of wire #2 was smoothed up to a depth of 0.25mm. Flat areas of elliptical shape, the total area of which constitutes 40% of the total wire area, were produced as a result of the smoothing. The fibrous layer was placed on the smoothed wire surface at the pressing stage.

Two fine-mesh wires joined together were used as a moistening belt. Each fine-mesh wire is made by simple interweaving of threads 0.25 mm in diameter, and there are 24 threads per 1 cm of running length. Moisture capacity defined as the amount of water retained by capillary forces in the wire of area 1 m^2 constitutes 0.08 kg/m^2.

The formed fibrous layer placed between the profiling wire (#1 or #2) and moistening wires was fed into the gap between the rolls of a roller press developing a force of 10 or 18 kg on 1cm of layer width. Subsequent to pressing, the moistening wires were taken off the fibrous layer, while the layer being held by profiling wire was fed to drying unit, the surface of which was heated to the temperature of 115 C.

Results of experimental testing are given in the Table below.

	Specific ravity of the layer of fibers, kg/m³	Moisture content of fibers on the forming wire, %	of profiling wire	Pressing force, kg	Moisture content of fibers after pressing, %	Tensile strength of paper sample, N/m	Moisture capacity of paper sample, kg of water per kg of absolutely dry fibers
1	0.04	35	1	10	52	600	2.2
2	0.045	35	1	10	54	550	2.1
3	0.04	30	1	18	43	850	1.9
4	0.04	32	1	18	45	870	1.9
5	0.04	35	1	18	47	960	1.9
6	0.045	30	1	18	45	840	1.8
7	0.045	35	1	18	48	850	1.8
8	0.04	30	2	10	48	550	2.3
9	0.04	35	2	10	51	550	2.2
10	0.045	30	2	10	49	620	1.8
11	0.045	35	2	10	50	640	1.9
12	0.04	30	2	18	48	670	2.2
13	0.04	35	2	18	51	700	2.1

The experiments performed confirm the possibility of implementing the method of the present invention and verified the above-indicated results. Using this method, it is possible to make tissue paper offering such strength and hygroscopic properties that correspond to the current specifications for tissue paper making. It should be pointed out that the amounts of water expended with this method are significantly less compared to the amounts spent when using other known methods. It can

be seen from the above Table that moisture content of the fibrous layer fed to drying subsequent to pressing varies only slightly compared to the moisture content of fibrous layer on the forming wire, which significantly reduces the cost of drying and decreases the shrinkage of paper web during drying.

Results of the experiments also indicate how parameters of technological process and equipment units exert influence on the final result. For example, when using wire #1 which is made out of flat threads and which has "shallow" relief formed by the interwoven nodes of threads, greater pressure should be applied to obtain required strength properties of the final product.

On the other hand, to obtain a required strength of tissue paper, quite high pressure is also needed when using wire #2 that is made of round threads and that has lesser area of pressing zones compared to wire #1. However, it is just the lesser area of pressing zones that makes it possible to obtain tissue paper offering greater absorbency than the tissue paper produced using wire #1.

Results of experiments given in the above Table in the 3rd, 4th, and 5th lines confirm that initial moisture content of a fibrous layer fed to a pressing operation also exerts impact on the strength of tissue paper being manufactured. The greater the moisture content of the fibers, the softer

and less twisted are they. Therefore, the contact area of such fibers is greater in the course of pressing. This fact results in the formation of inter-fibrous bonds on greater area, and, hence, in stronger tissue paper, while absorbency of such tissue paper remains the same.

While this invention has been described in connection with what is presently considered to be the most practical and preferred embodiments, it is to be understood that the invention is not limited to the disclosed embodiments, but, on the contrary, is intended to cover various modifications and equivalent arrangements included within the spirit and scope of the appended claims.